

BIG IDEAS:

- Extinction is part of nature.
- There have been at least five mass extinctions in the past, and humans are likely causing a sixth.
- Extinctions occur when species fail to adapt to changing ecological conditions.
- Some species are more prone to extinction than others.
- Extinction has consequences.

EXTINCTION:

Causes AND Consequences

Tuesday, June 26, 1804—It had been a trying day for the Corps of Discovery. After miles of rowing their keelboat upstream, the 12-ton vessel had become hopelessly beached on a sandbar. Fearing she might tip sideways and take on water, Captain William Clark ordered his men into the river to pull the boat free. The crew struggled for hours—and snapped two tow ropes—but eventually dragged the boat into deeper water. His men exhausted, Clark halted the expedition just a mile upstream. As the crew made camp near present-day Kansas City, Clark penned in his journal, “I observed an immense number of parakeets this evening.”

Although one might attribute Clark’s parakeet sighting to fatigue, the explorer was not hallucinating. Carolina parakeets were once common in forests from Virginia to Nebraska. With flashy green bodies, yellow heads and bright orange cheeks, the birds were unmistakable. About the size of a blue jay, the parakeets formed enormous, noisy flocks and were notorious for swarming crop fields and fruit orchards.

Lewis and Clark’s expedition marked the beginning of the end for the parakeet. Settlers followed the explorers westward, cutting down huge expanses of forest to clear space for crops. Farmers considered the bird a pest and slaughtered them by the thousands. Hunters also shot huge numbers, shipping the birds’ bright feathers east where they were used to decorate ladies’ hats. Pushed into ever smaller blocks of habitat and hunted by nearly everyone who owned a gun, parakeet populations plummeted. By 1870, Carolina parakeets were gone from Missouri. In 1904, the last parakeets in the wild disappeared. In September, 1914, the last Carolina parakeet on Earth died at the Cincinnati Zoo, marking the extinction of one of North America’s most colorful birds (*Figure 5.1*).

Extinction, or the complete elimination of an entire species, is the harshest reality of nature. Extinction cannot be undone—extinction is forever. In this chapter, we will investigate what causes extinction, compare past extinctions to recent ones, and examine the role humans play in the extinction of other species.

Extinction is part of nature.

Carolina parakeets, woolly mammoths and tyrannosaurs are just a few of many species that have vanished from Earth. In fact, fossil records reveal 99.9 percent of all species that ever lived are now extinct. This reveals that extinction isn't the unlikely fate of a few unlucky species, but rather a natural process that most

species are likely to face. Before we examine what causes extinction, it will be useful to distinguish between several types of extinction.

While camped at present-day Kansas City, the Corps of Discovery crew went hunting. According to Private Joseph Whitehouse, "The hunters killed five deer, one wolf and caught another about five months old. We kept it for three days. Cut its rope. Got away." As Whitehouse indicates, gray wolves once prowled northern Missouri. By the early 1900s, over a century of unrestricted hunting had eliminated them from the state. Although gone from Missouri, healthy wolf populations still exist in other places, such as Minnesota, Montana and Alaska. Ecologists use **extirpation** to refer to these local extinctions, when a species disappears from one location but survives in another.

As ecosystems change, some species disappear and others take their place. This **natural** or **background extinction** can be caused by several things. Some species cannot adapt quickly enough to keep pace with environmental changes. Others cannot survive predation from or compete with new species that show up. Some species are just in the wrong place at the wrong time and fall victim to chance catastrophes like fire, storm or disease.

Background extinction occurs at a relatively slow pace. By examining the fossil record, ecologists have found species generally exist for about one to 10 million years. Put another way, for any given year, a particular species has between a one in a million and a one in 10 million chance of going extinct. Earth likely contains between one and 10 million species. Thus, ecologists estimate background extinction should occur at a rate of one species per year.

Most ecologists believe current extinction rates are far higher than the expected background extinction rate. Just how many species disappear each year, however, is hotly debated. The renowned Harvard ecologist E.O. Wilson has calculated an extinction rate of 30,000 species per year. If his estimate is right, in the time it takes this class period to end, three to five species will have disappeared from Earth. Other estimates range from a few thousand to more than 100,000 species disappearing each year. Regardless of the actual number, the current extinction rate is cause for concern. In fact, ecologists believe we are in the midst of a **mass extinction**, the dying off of a large number of species in a relatively short span of time.

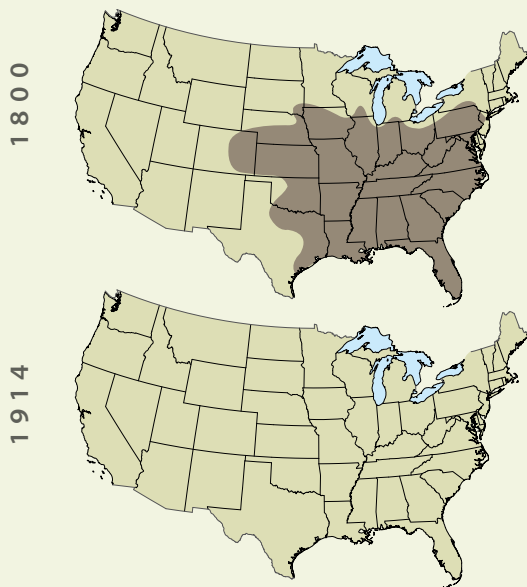


Figure 5.1—In the early 1800s, Carolina parakeets were common in forests from Virginia to Colorado (top). By the early 1900s, the parakeet had been completely eliminated from forests throughout the United States (bottom). In 1914, the last Carolina parakeet on Earth died, marking the species' extinction.

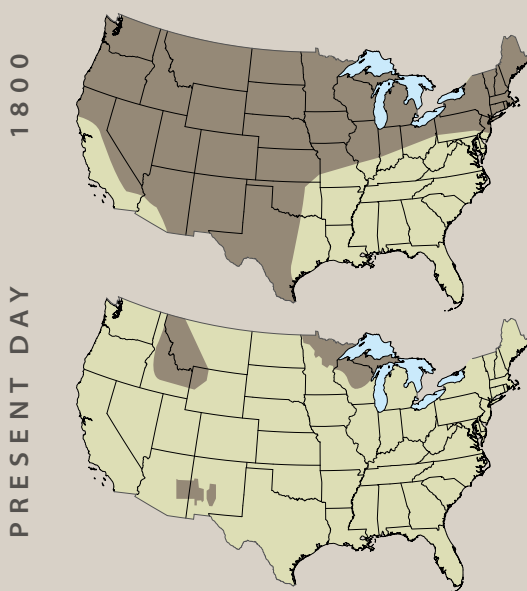


Figure 5.2—Before European settlement, gray wolves ranged throughout much of the United States (top). Wolves have since been extirpated from most of their historic range, but small populations still exist in several states such as Minnesota, Montana and New Mexico (bottom).

There have been at least five mass extinctions in the past, and humans are likely causing a sixth.

Late in the Cretaceous Period, about 65 million years ago, a *Tyrannosaurus rex* lifts its blood-splattered head from the carcass of a duck-billed dinosaur. A bright flash, like an enormous bolt of lightning, has caught the eye of the toothy scavenger. Seconds later, the ground shudders from some distant, but massive impact, and the T-rex lumbers toward the safety of a grove of palm trees. Then, the sky goes black.

Within a few hundred thousand years, Tyrannosaurs and most other dinosaurs had vanished. In fact, over half of Earth's species perished during this time. Many scientists believe that an asteroid (or maybe several) collided with Earth near present-day Mexico, kicking up a global cloud of dust that blotted out the sun. Scientists theorize this created a decade-long winter that led to the collapse of entire ecosystems.

Other scientists offer alternative explanations. About this time, a supercontinent called Pangea was breaking apart into the smaller continents we recognize today. As pieces of Pangea shifted, they altered ocean currents and climate patterns, creating a period of global cooling. Continental shifting also triggered the eruption of the Deccan Traps, a chain of immense volcanoes in India. These super volcanoes spewed out vast amounts of lava and belched climate-altering gases, further contributing to Earth's global cooling. Life could not adapt quickly enough to this rapid cooling, and over half the world's species disappeared. According to this theory, the asteroid was nothing more than the final nail in the dinosaurs' coffin.

The series of die-offs at the end of the Cretaceous marked the most recent mass extinction in Earth's history. By studying fossil records and other geological evidence, scientists have found proof of four other mass extinctions (Figure 5.3). There have probably been others. Although the cause of each mass extinction isn't completely understood, physical forces, such as falling sea levels, climate change or volcanic eruptions, are likely to blame.

The first mass extinction we know about occurred 445 million years ago. Nearly all life lived in water at this time. Scientists believe Pangea slowly drifted over the South Pole, causing glaciers to form, which pulled water from the oceans. Sea levels dropped worldwide—a possible cause of the disappearance of 57 percent of Earth's species.

The second mass extinction occurred about 370 million years ago. As plants adapted to life on land, they began removing large quantities of carbon dioxide from the

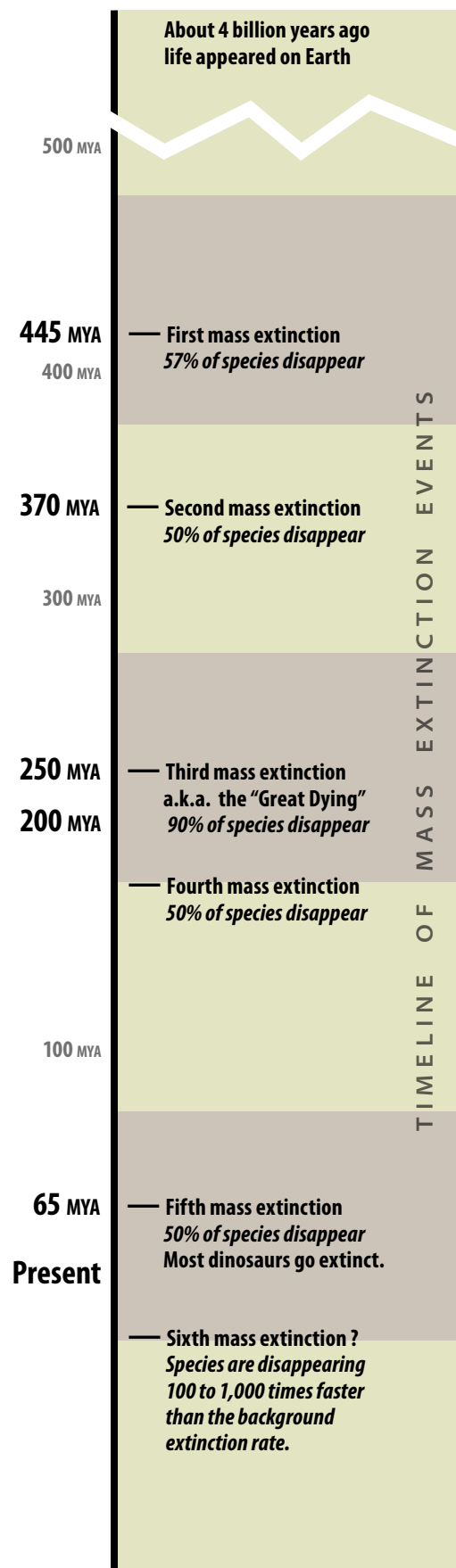


Figure 5.3—Timeline of Earth's Mass Extinctions (MYA - Million Years Ago)

atmosphere. This created a reverse greenhouse effect, causing the Earth to cool. Cooling temperatures fostered the formation of large land glaciers. This created a drop in sea levels, and thousands upon thousands of reef-building corals and shallow marine organisms—over 50 percent of Earth’s species—perished.

Earth’s third mass extinction occurred about 250 million years ago. This was the big one—the closest life has ever come to ending. Known to scientists as the “Great Dying,” 96 percent of sea life disappeared and 70 percent of all land vertebrates perished. All told, more than 90 percent of Earth’s species were wiped from the planet. Many events likely contributed to a mass extinction of this scale. Scientists have found evidence of colossal volcanic eruptions, some of which lasted hundreds of thousands of years. In addition, Pangea was on the move again. This time, its change in position likely altered ocean currents. Both events, along with a possible meteor strike, cooled the Earth to the point where most life ceased to exist.

The fourth mass extinction wiped out more than 50 percent of Earth’s species alive at the time. The likely cause was the eruption of a chain of volcanoes in the Atlantic Ocean. Every few centuries, these mega-volcanoes spewed out millions of cubic kilometers of lava and belched quadrillions of kilograms of sun-blocking sulfur. This resulted in a roller coaster of global cooling and warming, and many species couldn’t survive the ride.

Earth is in the middle of a sixth mass extinction. In Missouri, conservationists are concerned about more than 600 kinds of plants and more than 300 kinds of animals because their numbers are extremely low or declining rapidly. According to data compiled by the World Conservation Union, 12 percent of Earth’s birds, 20 percent of its mammals and 31 percent of its amphibians are **endangered**, or at risk of going extinct in the near future. Ecologists estimate species are disappearing 100 to 1,000 times faster than the expected background extinction rate.

The current mass extinction is unlike any that have occurred previously. Evidence indicates that past mass extinctions were caused by abiotic forces such as volcanic eruptions, asteroid collisions, shifting continents and changes in sea levels. In contrast, most scientists agree that today’s mass extinction is directly or indirectly caused by biotic forces, namely human beings. To understand the role humans play in this sixth mass extinction, we need to examine the causes of extinction.

Extinctions occur when species fail to adapt to changing ecological conditions.

Why do species go extinct? In the broadest sense, extinction is a result of natural selection—species disappear when they fail to adapt to changing ecological conditions. In more specific terms, species disappear when deaths exceed births over a long enough period. Thus, any process that lowers birth rates

or increases death rates can cause a species to go extinct. Such forces may act independently or team up on a species to bring about its demise. Ecologists pin current extinction on four primary causes, each of which is directly or indirectly influenced by the actions of humans.

Habitat Destruction

Habitat destruction and **fragmentation**, the carving of large blocks of habitat into smaller, scattered pieces, are the biggest threats to most species. Without adequate habitat in which to grow, survive and reproduce, births decrease, deaths increase, and it isn’t long before species goes extinct.



Human development, such as subdivisions, can fragment large blocks of habitat into smaller, scattered pieces.

Invasive Species

Wherever humans have traveled, we have accidentally or deliberately brought other species with us. Non-native species like European starlings, emerald ash borers, zebra mussels and sericea lespedeza are often invasive, adapting quickly to new locations and pushing out native species. Invasive species do this by altering habitats, competing for limited resources or preying directly upon native species.

Overexploitation

Some organisms are hunted, fished or harvested to extinction. Technology has provided humans with tools, such as firearms, nets and chainsaws, that many species cannot defend against. When we use these tools without restraint, we can cause species to go extinct.

At one time, passenger pigeons were the most abundant bird on the planet. The naturalist John James Audubon watched a flock pass overhead for three days and estimated that 300 million birds flew by each hour. Passenger pigeons had two traits, however, that brought about their demise: they tasted good and they were easy to kill. To supply meat to expanding cities, hunters fired into the enormous flocks, killing dozens of birds with each shot. Pigeons were baited with alcohol-soaked grain that made them drunk and easy to catch. Some hunters clipped the wings of captive pigeons and used them as live decoys. During the height of the pigeon slaughter, hunters killed nearly 400,000 pigeons each month in Michigan alone. In 1914, the last surviving member of a species that once numbered 5 billion strong died at the Cincinnati Zoo.

Climate Change

Every organism is adapted to live within a particular range of environmental conditions. If abiotic factors such as temperature, precipitation or oxygen concentration shift outside the range required by a particular species, the existence of that species in that particular habitat becomes impossible. Changes in global temperatures have wide-ranging effects on environmental conditions and are expected to cause population declines in species ranging from tropical corals to Midwestern mammals.

Many scientists believe that human activities, such as the burning of fossil fuels, are contributing to increases in global temperatures. Other scientists dispute this claim, arguing that temperature increases are part of Earth's natural climate cycle.



European starlings are aggressive birds that compete with native species for nest sites and other resources.



Market hunters drove passenger pigeons to extinction and nearly wiped out many other species.



Many scientists believe burning fossil fuels, such as coal, contributes to increasing global temperatures.



Battling Exotic Invaders

To most, exotic brings to mind something unique, rare and beautiful. To a resource manager, exotic means something completely different. **Exotic, non-native or introduced** species all refer to an organism that has moved into an area in which it previously did not exist. Scientists estimate that over the past century close to 4,500 exotic plants and animals have moved into North America. While some, like the honeybee, have been beneficial, others have wiped out native populations and devastated local ecosystems. Resource managers refer to these species as **invasive** because they spread rapidly and harm native organisms.

Most invasive species grow quickly, reproduce often and bear many offspring. Limiting factors that keep them in check in their original environments, such as predators, competitors or disease, may not be present in their new locations. Native organisms rarely have adaptations to compete with invading species or fend off their attacks. As a result, the native organisms are often displaced or go extinct. Invasive species disrupt ecosystems, damage agricultural crops, and spread disease to native and domesticated plants and animals. An ever-increasing part of resource management is stopping the spread of these unwanted plants and animals. Here are a few of Missouri's worst invasive species and what managers are doing to stop their spread.

There's a killer loose in Missouri's forests.

A centimeter-long, metallic green beetle called the emerald ash borer has killed more than 50 million ash trees throughout North America. The beetle's wormlike larvae feed on tissues under the bark of ash trees. Over time, this cuts off the tree's supply of water and nutrients, and the tree eventually dies. No ash is safe from this tiny but destructive pest, and scientists are worried it could wipe out all of North America's ash trees.

Although scientists aren't sure exactly how the insect arrived in the United States, it most likely hitched a ride in wooden packaging materials, such as crates or pallets, shipped from Asia. Although adult beetles rarely fly far from the tree where they hatch, both adults and larvae can hitchhike long distances in firewood. This is likely how emerald ash borer ended up in Missouri.

To date, a cost-effective way to eradicate emerald ash borer has not been found. Pesticides have been developed that will kill the insect, but they are not safe, practical or economical to use over a widespread area. Instead, managers are working hard to slow the beetles' spread. Scientists survey forests, parks and other areas to detect new outbreaks, and inspectors perform regular checks on nurseries and lumber mills. If an infestation is found, managers set up quarantines and enforce laws to prevent the removal of ash logs, nursery trees and firewood from the area. Ads and radio announcements are used to educate the public about the threat of emerald ash borer and the danger of moving firewood. In Asia, scientists have observed parasitic wasps attacking emerald ash borer eggs and larvae. Efforts are underway to determine if these wasps could be safe and effective to control emerald ash borer in North America.



Emerald ash borers kill ash trees.

A mini-monster is "musseling" into Missouri's waterways.

A fingernail-sized mollusk is taking over waterways across North America. Zebra mussels, which look like black-and-white striped clams, are native to the Caspian Sea. They were transported to North America in the bilge water of ships and first discovered in waters near Detroit in 1988. Since then, these invasive mussels



Zebra mussels, shown here attached to a native mussel, compete with native species for food and living space.

have spread rapidly throughout the Great Lakes, worked their way into the Mississippi and Missouri rivers, and turned up in several Missouri lakes.

Female zebra mussels can produce 1 million eggs each year. These develop into free-swimming larvae that disperse with currents, settle onto firm surfaces and quickly form dense colonies. At a power plant on Lake Erie, zebra mussels went from undetectable levels in 1988 to 700,000 per square meter in 1989.

Zebra mussels feed on plankton, the microscopic plants and animals that form the basis of the aquatic food chain. This puts them in direct competition with native mussels and young fish, including bass and bluegill. Zebra mussels can blanket native mussel colonies and prevent them from

getting nutrients. Large colonies of zebra mussels can remove enough oxygen from the water to cause fish kills. Removing zebra mussels from boats, docks and water intakes is expected to cost billions of dollars over the next decade.

Zebra mussels spread to new water by hitching rides on boats, trailers and other marine equipment. Resource managers are urging people to keep zebra mussels from spreading by washing their boats and trailers with hot water between trips and letting them dry in the sun for at least five days. This will kill any zebra mussels that might be attached.

This plant won't stay put.

Once called "poor man's alfalfa," sericea lespedeza was initially introduced to the United States from eastern Asia as a pasture crop. It first appeared in Missouri in the 1930s, when it was planted for livestock forage, erosion control and wildlife food. Since that time, both livestock producers and resource managers have realized sericea's disadvantages far outweigh its possible benefits.

Wildlife, such as quail, will eat sericea seeds, but are unable to fully digest them because of the hard outer shell. Cattle only eat the tender new growth of young sericea plants because the mature plant is too tough. When mature, sericea is tall and dense enough to block sunlight from other plants. It also saps water from the soil, and its roots produce chemicals that hinder the growth of other plants. Once it gains a foothold, sericea quickly overtakes an area, crowding out all other plants.



Sericea lespedeza crowds out native plants and provides little for wildlife.

A single stem of sericea can produce more than a thousand seeds. Because its seeds float, the plant spreads easily throughout watersheds. Birds and other animals also distribute the seeds. Fortunately, sericea is fragile during its seedling stage and slow to establish. Unfortunately, once established, it's tough to get rid of.

Resource managers scout public lands across the state to keep tabs on sericea. When found, managers try to eradicate the plant using a combination of burning, mowing and herbicide application. Since sericea seed can stay viable in

the soil for many years, repeated treatments are needed to completely eradicate an established population. Researchers are currently working on quicker, easier and cheaper ways to get rid of this pesky plant.



Restoring Grasslands, Saving Birds

A biological crisis is unfolding across America's Great Plains. Populations of grassland birds are disappearing from many areas and declining at an alarming pace in others. Breeding bird surveys conducted by biologists and birdwatchers throughout the country reveal that of the 42 grassland birds monitored annually, 23 are showing significant population declines. The surveys also show that, as a group, grassland

birds are declining faster and more consistently than birds in other ecosystems, such as wetlands or forests. Some of America's best-known birds, such as meadowlarks, bobwhite quail and prairie-chickens, have declined by 38 to 77 percent since 1968.

Such staggering losses illustrate the effect of limiting factors. Each kind of grassland bird has a unique list of habitat requirements that must be met for it to survive and reproduce. When grasslands are plentiful, those requirements are met. When grasslands disappear, those requirements aren't met, and the lack of habitat acts as a limiting factor.

In the early 1800s, prairies covered more than a third of Missouri, or 6 million hectares. Today, less than 1 percent—just 30,000 hectares—remains. Native prairies support more than 200 kinds of grasses and wildflowers, providing birds a buffet of food,

nesting sites, places to raise chicks and cover to escape from predators. Grassy fields today often contain only one type of plant, a non-native grass called tall fescue. Without the diversity provided by native prairies, grassland birds have a tough time finding the things they need to survive and reproduce. Although birds may use these crop fields, golf courses and pastures, haying, grazing and frequent disturbance by people can create **population sinks** where birds try to nest but fail to raise their young.

While loss of grassland habitat is the primary limiting factor, others also play a role. The increased use of pesticides and herbicides can be toxic to birds or kill the insects and weeds they feed on. Feral cats and hogs eat adult birds or their eggs. Droughts and loss of wintering habitat in Central and South America contribute to declines.

The situation isn't hopeless. In the 1970s, wetland birds faced a similar crisis. Today, many wetland birds are showing an upward trend. The key to this reversal of fates has been coordinated efforts by government agencies, nonprofit groups and private landowners to protect and restore millions of acres of wetland habitat. Resource managers and private landowners are using this as a model for reversing the downward spiral of grassland bird populations. Here are some of the things they're doing:

- Federal, state and nonprofit agencies along with private landowners are restoring native prairies throughout the state. This involves eradicating non-native vegetation in an area and reseeding the ground with native grasses, wildflowers and shrubs.
- Many row crop farmers are taking advantage of incentives offered in the federal Farm Bill that pay landowners to leave weedy borders around the edge of their corn, soybean and wheat fields. These borders provide much-needed habitat for grassland birds.
- An increasing number of cattle farmers are converting their pastures from nonnative grasses that don't benefit wildlife to native prairie grasses that do. The prairie grasses provide an excellent food for cattle and great habitat for birds. Landowners are encouraged to hold off haying these pastures until after nesting season, giving birds a chance to hatch and raise their young.
- If left alone, prairies in Missouri soon become covered with shrubs and trees. Before settlement, trees were kept at bay by grazing herds of bison and elk or fires set by lightning or Native Americans. Nowadays, resource managers try to recreate these natural disturbances by grazing cattle, using mowers and disks, and setting prescribed fires.

Eastern meadowlark



Some species are more prone to extinction than others.

Why do some species, like Carolina parakeets, go extinct, while others, like cockroaches, survive for eons? It turns out that certain traits make some species more prone to extinction than others.

One way ecologists group species is based on the range of habitats and environmental conditions in which they can survive. Some, like white-tailed deer, can live in many kinds of habitats and survive a wide range of environmental conditions. Ecologists call these kinds of species **generalists**. Put another way, generalists have a broad niche. In contrast, species like Indiana bats that hibernate in just a few caves throughout the Midwest and that survive in only a narrow range of environmental conditions are called **specialists**. Specialists have a narrow niche. Because their niche requirements are more difficult to meet, specialists are more prone to extinction than generalists.

All else being equal, small populations are more likely to go extinct than large populations. Consider your bank account. If you have \$1,000 in your account, losing \$5 has little effect. If, however, you have only \$10 in your account, losing \$5 means you've lost 50 percent of your savings. Deaths affect small populations in much the same way. Because they have less genetic variation and are thus less able to adapt, small populations are more likely than large populations to be wiped out by disease, parasites and changing environmental conditions. Small populations often possess less genetic variation than large populations because of **inbreeding**, which occurs when two closely related individuals mate and produce offspring. And, a phenomenon known as the **Allee effect** can draw small populations toward extinction by affecting behaviors that depend on high population densities. For example, when population densities are low, it may be hard for individuals to find mates (which affects births) or group together in herds, flocks or schools for defense (which affects deaths).

In general, species that inhabit a large geographic area are less likely to go extinct than species that inhabit a more restricted geographic area. Extensive geographic ranges offer a buffer against environmental change. Therefore, if environmental conditions change and kill off populations in one area, populations of the same species in other areas can still survive.

Taken together, niche tolerance, population size and geographic range help ecologists predict whether or not a species is prone to extinction. As shown in Figure 5.4, there are eight possible combinations of these factors. Species that are least likely to go extinct are generalists with large populations that have extensive geographic ranges. In contrast, species most likely to go extinct are specialists with small populations that occupy restricted geographic ranges.



White-tailed deer are considered generalists because they can live in a variety of habitats. Because they have strict habitat requirements, Indiana bats are considered a specialist species.










Risk of Extinction	Traits	Examples
	Generalist Large population Extensive range	White-tailed deer 
	Generalist Large population Restricted range	Eurasian tree sparrow 
	Specialist Large population Extensive range	Morel mushroom 
	Generalist Small population Extensive range	Peregrine falcon 
	Specialist Large population Restricted range	Niangua darter 
	Generalist Small population Restricted range	Running buffalo clover 
	Specialist Small population Extensive range	Indiana bat 
	Specialist Small population Restricted range	Ozark cavefish 

Figure 5.4—There are eight possible combinations of niche tolerance, population size and geographic range. These factors help predict how prone a species is to extinction.

Extinction has consequences.

Why should we care whether or not a species goes extinct? For many, extinction is a moral issue. Because humans have destroyed habitats, introduced invasive species, over-harvested populations and possibly contributed to climate change, many people believe it is our moral responsibility to correct these problems and save species from extinction.

In addition, many species provide economic benefits to humans. Some plants and animals are important food resources. Others, like trees, provide products such as lumber, paper and rubber. Several medicines, including anesthetics important for pain relief, are derived from flowering plants. Many people enjoy hunting, fishing or nature viewing and pay money to do so.

The greatest risk of extinction, however, relates to the role each species plays in a biological community. As we learned in chapter four, species maintain balance within communities by keeping other populations in check through competition, exploitation and mutualism. Large predators, such as wolves and mountain lions, have been extirpated from Missouri and many other areas of the country. In many ecosystems, human hunters have taken over as the major predator keeping prey populations in check. But, in areas without large predators—human or otherwise—prey populations can skyrocket and cause problems. For example, too many white-tailed deer in a forest can create browse lines where every scrap of vegetation

is eaten from the ground to as high as a deer can reach. This affects not only the plants the deer have eaten, but also animals that rely on those plants for food and shelter. In the end, it even affects the deer themselves, because many deer eventually starve when food runs out.

One might argue that not every species plays a major role in an ecosystem. The extirpation of white-footed mice from a forest would probably have little effect on the forest community. Other species, such as deer mice and woodland voles, have similar niches and play similar roles. If several of these small mammal species are extirpated, however, species that prey upon them, such as snakes, hawks, bobcats and foxes, also begin to dwindle. A community is a bit like an automobile in this regard. Like a biological community, an automobile has thousands of major and minor parts that keep it running. Lug nuts, for example, secure the wheels of an automobile to the axle. Most vehicles have four to eight lug nuts on each wheel. This way, if one falls off, others remain to hold the wheel in place. If several are lost, however, it isn't long before the wheel falls off and the car crashes. In the same way, if too many species go extinct or are extirpated from a community, it isn't long before the community crashes.

In the chapters that follow, we'll expand our exploration of the role species play in communities and ecosystems. We'll learn how energy flows through communities, how elements cycle through ecosystems and what factors influence the amount and variety of species that live in an area. We start this exploration in Chapter 6 by examining how energy from the sun is transferred through food chains and food webs. ▲

The extirpation of white-footed mice probably would have little effect on a forest community. If several small mammals were extirpated, however, predator populations, such as snakes, would soon dwindle. And, if too many species were extirpated, it wouldn't be long before the community crashed.





Missouri's wetlands produce more life than nearly any other place on Earth. Only tropical rainforests and coastal salt marshes yield more life per square meter.